Complex Problems – Part Deux

#1 The following illustrates what happens during this event:

START → | → FINISH

rxn time – uniform motion decelerates to a stop

$\vec{v} = 100\ km/h = 27.78\ m/s$
$\Delta t = 0.50\ s$
$\Delta \vec{d} = ?$

$\vec{v} = \Delta \vec{d} / \Delta t$
$\Delta \vec{d} = 13.89\ m$

$\vec{v}_1 = 27.78\ m/s$
$\vec{v}_2 = 0\ m/s$
$\vec{a} = -6.0\ m/s^2$
$\Delta \vec{d} = ?$

~~#~~

$\vec{v}_2^{\,2} = \vec{v}_1^{\,2} + 2\vec{a}\Delta\vec{d}$
$0 = 27.78^2 + 2(-6)\Delta\vec{d}$
$\Delta\vec{d} = 64.3\ m$

$\therefore$ Total Stopping Distance $= 78.2\ m$

#2 Same sketch as above:

$\vec{v} = 27.78\ m/s$
$\Delta t = 0.40\ s$
$\Delta \vec{d} = ?$

$\Delta \vec{d} = \vec{v}\Delta t$
$= 11.11\ m$

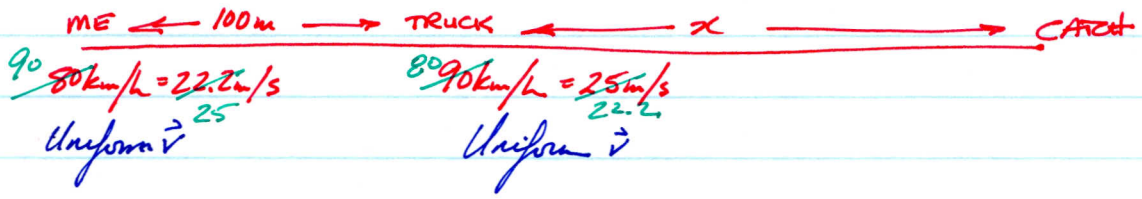
$\vec{v}_1 = 27.78\ m/s$
$\vec{v}_2 = 0\ m/s$
$\vec{a} = -2\ m/s^2$
$\Delta \vec{d} = ?$

~~#~~

$\vec{v}_2^{\,2} = \vec{v}_1^{\,2} + 2\vec{a}\Delta\vec{d}$
$0 = 27.78^2 + 2(-2)\Delta\vec{d}$
$\Delta\vec{d} = 192.9\ m$

$\therefore$ Total Stopping Distance $= 204\ m$

#3 This question should be familiar to you — Alex/Mom/sandwich.



$\vec{v} = 22.2$ m/s 25

$\Delta\vec{d} = x + 100$ ← has to travel additional distance

$\Delta t = t$ ← same time interval for both →

$\vec{v} = 25$ m/s 22.2

$\Delta\vec{d} = x$

$\Delta t = t$

~~$\Delta\vec{d} = x + 100$~~ $\Delta\vec{d} = \vec{v}\Delta t$

~~$x + 100 = 22.2t$~~ ①

$x + 100 = 25t$

$\Delta\vec{d} = \vec{v}\Delta t$

~~$x = 25t$~~ ②

$x = 22.2t$

Substitute ② into ①

~~$25t + 100 = 22t$~~ $22.2t + 100 = 25t$

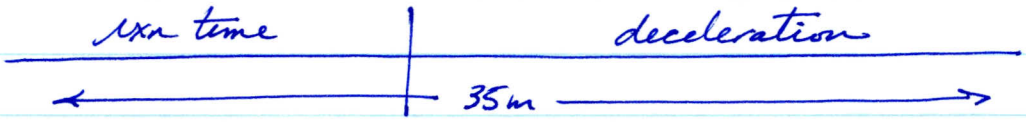
$t = 33.3$ s $t = 35.7$ s

$\Delta\vec{d} = \vec{v}\Delta t$

$= 22.2 (35.3)$ (25)

$\doteq 739$ m (892.5)

#4 Scenario



$v = 50\ km/h$

Her rxn time is 0.30s. This means she has 2.2 seconds over which to safely stop. What distance does she have to stop and can she accomplish this in 2.2 seconds or less?

$\Delta t = 0.30s$

$\Delta \vec{d} = ?$

$\Delta \vec{d} = \vec{v}\Delta t$

$= (13.89)(0.30)$

$= 4.167m$ → Thus she has 30.833m to decelerate.

$\vec{v}_1 = 13.89\ m/s$

$\vec{v}_2 = 0\ m/s$

$\Delta \vec{d} = 30.833m$

$\Delta t = ?$

$\vec{a} = -6.0\ m/s^2$

$\vec{v}_2^{\,2} = \vec{v}_1 + 2\vec{a}\Delta\vec{d}$

$0^2 = 13.89^2 + 2(-6)\Delta\vec{d}$

$\Delta \vec{d} = 16.1m$

Based on this information, she will come to a complete stop in 16m, well before the intersection (14m to spare). No need to worry about the time factor.

#5 Revision to the scenario

1x1 time | accelerate

$V = 50 km/h = 13.89 m/s$

$\Delta t = 0.30 s$

$\Delta d = ? = 4.167 m$ (from before)

This time her target is $35m + 12m = 47m$ away. From the moment she steps on the gas, she is 42.833 m away.

What is her acceleration rate?

$\vec{V}_1 = 13.89 m/s$

$\vec{V}_2 = 70 km/h = 19.44 m/s$

$\vec{a} = ?$

$\Delta t = 7.0 s$

$\vec{V}_2 = \vec{V}_1 + \vec{a}\Delta t$

$19.44 = 13.89 + 7a$

$\vec{a} = 0.794 m/s^2$

Can she accelerate through the remaining distance in under 2.2 seconds?

$\vec{V}_1 = 13.89 m/s$

$\vec{a} = 0.794 m/s^2$

$\Delta t = ?$

$\Delta \vec{d} = 42.833 m$

$\Delta \vec{d} = \vec{V}_1 \Delta t + \frac{1}{2} a \Delta t^2$

$42.833 = 13.89\Delta t + 0.397 \Delta t^2$

a quadratic! $0.397\Delta t^2 + 13.89\Delta t - 42.833 = 0$

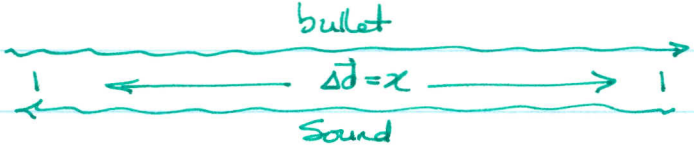
$$\Delta t = \frac{-13.89 \pm \sqrt{13.89^2 - 4(0.397)(-42.833)}}{2(0.397)}$$

$$= \frac{-13.89 \pm \sqrt{260.95}}{0.794}$$

$= 2.85 s$

→ does not beat the red light.

#6 Image:



Uniform velocity for each.

Bullet

$\Delta\vec{d} = x$

$\Delta t = t$ ← time for bullet to travel

$\vec{v} = 1600\ m/s$

$\Delta\vec{d} = \vec{v}\Delta t$

$x = 1600t$ (1)

Sound

$\Delta\vec{d} = x$

$\Delta t = 0.731 - t$ ← remaining time

$\vec{v} = 340\ m/s$

$\Delta\vec{d} = \vec{v}\Delta t$

$x = 340(0.731 - t)$

$x = 248.54 - 340t$ (2)

Equate (1) and (2)

$1600t = 248.54 - 340t$

$t = 0.128\ s$

Thus $\Delta\vec{d} = x = 1600(0.128)$

$= 205\ m$

#7

$\vec{v} = 60\,km/h = 16.67\,m/s$

$\Delta\vec{d}$ = need this in order to find Δt

$\Delta t =$

$\vec{v}_1 = 16.67\,m/s$

$\vec{v}_2 = 0\,m/s$

$\vec{a} = -7.0\,m/s^2$

$\Delta\vec{d} = ?$

$$\vec{v}_2^{\,2} = \vec{v}_1^{\,2} + 2\vec{a}\,\Delta\vec{d}$$

$$0 = 16.67^2 + 2(-7)\,\Delta\vec{d}$$

$$\Delta\vec{d} = 19.85\,m$$

Thus, he travelled 3.45 m during his reaction time.

$$\Delta\vec{d} = \vec{v}\,\Delta t$$

$$3.45 = 16.67\,\Delta t$$

$$\Delta t = 0.21 \text{ seconds.}$$

#8 Flyer ← 250m → Express

$\vec{v}_1 = 110 km/h = 30.56 m/s$
$\vec{a} = -3 m/s^2$

$\vec{v}_1 = 96 km/h = 26.67 m/s$
$\vec{a} = -4.0 m/s^2$

how far will each travel in coming to rest?

$\vec{v}_2 = 0 m/s$
$\Delta\vec{d} = ?$

$\vec{v}_2^2 = \vec{v}_1^2 + 2\vec{a}\Delta d$
$0 = 30.56^2 - 6\Delta\vec{d}$
$\Delta\vec{d} = 155.65 m$

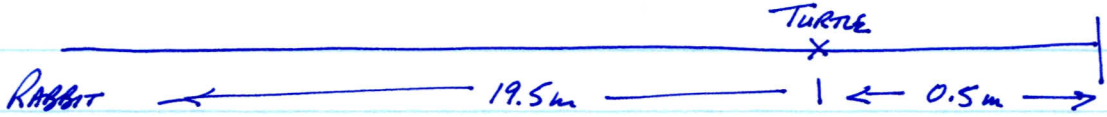
$\vec{v}_2 = 0 m/s$
$\Delta\vec{d} = ?$

$\vec{v}_2^2 = \vec{v}_1^2 + 2\vec{a}\Delta\vec{d}$
$0 = 26.67^2 + (-8)\Delta\vec{d}$
$\Delta\vec{d} = 88.9 m$

Total distance = 244.6 m

∴ No collision ⇒ ~5m to spare

#9



It will take the turtle 2.0 s to win. ∴ Rabbit has to accomplish his task in under 2.0 s.

$\vec{v} = 0.25\,m/s$
$\Delta\vec{d} = 0.5\,m$
$\Delta t = ?$

$\Delta t = \Delta\vec{d}/\vec{v}$
$= 2.0\,s$

How long does it take the Rabbit to get up to top speed?
How far does he travel in doing so?
How long does it take him to cover the remaining distance?

$\vec{v}_1 = 0\,m/s$
$\Delta t = ?$
$\vec{a} = 9.0\,m/s^2$
$\vec{v}_2 = 18\,m/s$

$\vec{v}_2 = \vec{v}_1 + \vec{a}\Delta t$
$18 = 0 + 9\Delta t$
$\Delta t = 2.0\,s$

$\vec{v}_1 = 0\,m/s$
$\Delta\vec{d} = ?$
$\vec{a} = 9.0\,m/s^2$
$\vec{v}_2 = 18\,m/s$

$\vec{v}_2^{\,2} = \vec{v}_1^{\,2} + 2a\Delta\vec{d}$
$18^2 = 2(9)\Delta\vec{d}$
$\Delta\vec{d} = 18\,m$

After 2.0 s the rabbit is only at the 18.0 m mark

∴ No Dice!